Method and device for localizing the position of at least two

emission units, especially for monitoring at least one

5   parameter for a plurality of wheels pertaining to a motor

vehicle

The invention relates to a method and device for localizing

the position of at least two emission units, especially for

10   monitoring at least one parameter for a plurality of wheels

pertaining to a motor vehicle.

Monitoring the parameters of a wheel of a motor vehicle, for

example, the tire pressure or the tire temperature is

15   important for the reliability of the vehicle and/or the safety

of the driver of the vehicle. In order to make the manual

examination of such parameters unnecessary, devices were

developed by means of which it is possible to automatically

detect the important parameters of the wheels of a motor

20   vehicle and to indicate them, for example, by means of

corresponding display devices in the instrument panel. Because

the usual requirement is to not only show the parameters, but

also to ambiguously allocate the parameters shown to the

position of the relevant wheel, it is necessary to develop

25   such a device in such a way that this allocation is also

retained or can be re-initialized after a wheel has been

changed.

To this end it is known that a receiver unit has to be
allocated to each detector device which has been fitted to a
wheel, in each case, and said receiver unit provided in the
vicinity of the relevant wheel position. In this way, on the
basis of the intensity of the signals received by a receiver
unit it is possible to determine the signal of the neighboring
detector device, in each case, by selecting the signal with
the highest intensity. For this purpose it is assumed that the
detector devices of the wheels of a motor vehicle essentially
transmit with the same transmitting power so that the signal
of the immediately neighboring wheel in each case or the
neighboring detector device has the highest signal intensity
at the receiving point.

However, a disadvantage of such a device is the fact that each
wheel requires a receiving device whose reception signal then
has to be connected via a line to a central evaluation and
control unit or directly to a display unit.

From EP-A-0 806 306, an air pressure control system is known
in which the allocation of the positions of the wheels to the
air pressure control devices which are fitted to the wheels is
made possible by the fact that with the air pressure control
devices and in each case with an additional measuring device

allocated to the wheels, an additional parameter is detected

for each wheel. In this case, it can, for example, be the

speed of the wheels. To this end, the air pressure control

devices do not only transmit the measured values for the air

5   pressure, but also measured values for the additional

parameters to a central unit. Because for the same additional

parameters, measured values are also transmitted from the

additional measuring devices to the central unit, said central

unit can, by comparing the measured values for the additional

10   parameter allocate an air pressure control device to a wheel

position if the measured value supplied by the relevant air

pressure control device for the additional parameter

corresponds accurately enough with the relevant measured value

of the parameter of an additional measuring device. This is so

15   because the additional measuring devices are fitted securely

to the motor vehicle (not on the wheel) and as a result of

this remain allocated permanently to a specific position of

the wheel.

20   A disadvantage of this device is the fact that additional

costs are incurred for the two sensors for detecting the

additional parameter. Even if the additional parameters can be

detected with that sensor which is anyhow provided on the

wheel for detecting the air pressure, an additional sensor

25   fitted securely to the vehicle is required per wheel for

detecting the additional parameter.

Finally, from EP-A-O 931 679, a method for allocating the position of a wheel of a motor vehicle is known in which the transmission signals of the emission units allocated to the

5   wheel are transmitted to a central receiver unit and an evaluation unit and in which the different characteristic effects of the individual transmission paths when the wheels are rotating are extended to the specific reception signal in order to allocate the signals to the positions of the wheels.

10   This involves comparing the envelope of the reception signal which is amplitude-modulated by the time-variant changes of the transmission characteristics with stored signatures. However, a disadvantage is the fact that detecting and evaluating the envelope of said signal is relatively costly.

15   This requires both a large memory and extensive computation.

Therefore it is the object of the invention to create a method and a device for localizing the position of at least two emission units, especially for monitoring at least one

20   parameter for a plurality of wheels pertaining to a motor vehicle, with localizing able to be carried out in a simple way and with the required reliability, while at the same time aiming to keep hardware costs as low as possible.

25   The object of the invention is achieved with the features of claim 1 or 8.

The invention is based on the finding that, in the case of data transmission by means of a preferably phase-modulated or frequency-modulated signal, the signal power occurring at the receiving point of a central evaluation and control unit is influenced by the characteristics of the transmission path between the detector unit fitted to a wheel and the evaluation and control units. In this case, the characteristics of the transmission path are determined on the one hand by the angular position of the wheel and thereby the position of the detector unit and on the other hand by the parts or regions of the motor vehicle influencing the signal transmitted from the relevant angular position. In practice it has been shown that when the wheels are rotating, the transmission paths are in each case different in the different positions of the wheels and are at the same time a characteristic feature of the positions of the wheels.

Therefore, according to the invention the average signal power of the reception signal of an evaluation and control unit is preferably evaluated in order to make possible the allocation of a reception signal or the relevant emission unit to a wheel position or an axle position.

Generally speaking, a part N of the emission units is allocated to a first transmitter group and the other part M of

the emission units to a second transmitter group in which case
a local region is allocated to each transmitter group, for
example, the position region "rear axle" or the position
region "front axle". This forming of transmitter groups can
5   either be carried out for reasons of a more simple evaluation
or because the transmission paths anyhow do not influence the
transmitted signals to such a different extent that these, at
the location point of the receiver antenna of the receiver
unit, have a sufficiently different (averaged over a long
10   period of time) average power and as a result by only carrying
out a simple evaluation of the average power, a distinction
can hardly be made or in any case not with the required
reliability.

15   However, individual emission units can as a matter of course
also be localized with the method according to the invention.
Especially, the method of dividing the emission units into two
groups can be used repeatedly in succession. For example,
after allocating the emission units to the two transmitter
20   groups, the method can on the other hand again be used on each
one of the two groups, i.e. each group is again divided into
two subgroups in its turn.

According to the invention, the N emission units of all the
25   N+M emission units are in each case allocated with the N
highest average values of the reception signal to the first

-6-

transmitter group and thereby allocated to the relevant local region and the M emission units with the M lowest average values of the reception signal to the second transmitter group or the relevant local region in each case.

5

The minimum interval of the average power of the reception signals of the two transmitter groups is used as a measure of the reliability of the allocation; in other words: That reception signal standing at the Nth position in the ranking

10 of decreasing average power and the signal in the (N+1)th position are evaluated. As a measure of the interval it is, for example, possible for the absolute difference in level of the signals or the ratio of the signals to be evaluated. If the interval exceeds a predetermined threshold value, then the

15 result of the allocation carried out in the said manner (with sufficient reliability) will be deemed to be applicable. Otherwise, at least one additional decision criterion is used for allocating the reception signals or the relevant emission units to the transmitter groups or their local regions and/or

20 an additional criterion for testing the reliability of the correct allocation, preferably by using additional characteristic variables of the reception signals.

According to an embodiment of the invention, the final result

25 of the allocation is only deemed to be correct if all the allocation results, by using the one decision criterion or a

-7-

plurality of additional decision criteria, correspond with the first allocation result and possibly even then if the first and also all the additional decision criteria yield a negative result when testing the reliability of a correct allocation. The allocation can also be deemed to be correct even if the application of the last criterion for testing the reliability of the allocation should reveal that the reliability of the reliability is insufficient. In this case, because of the correspondence of the allocation results as such, a sufficient reliability can be assumed.

Otherwise, the allocation result is rejected and an error signal is generated if necessary.

Therefore the overall execution sequence of the method is as follows: First of all, an allocation of the emission units to the transmitter groups or their local regions is carried out by evaluating the average values of the reception signals and the reliability of the allocation is evaluated by using the first criterion for examining the reliability. In the level of reliability is sufficient, the method ends. Otherwise, an additional criterion for allocating the emission units is used and the result is checked by using an additional reliability criterion. If the last criterion made available for the specific method applies in this case and in the case of a correspondence of the allocation results, even if the last

reliability criterion yields a negative result, i.e. displays an insufficient reliability (when using the last criterion for the allocation), the allocation is assumed to be correct. If the allocation results do not correspond, the method will be terminated with an error message and an error signal will be generated if necessary. If the last criterion made available for the specific method does not apply in this case, then in the case of a negative result when examining the reliability, the next criterion to be used will be applied, etc.

In the case of the preferred embodiment of the method, the reception signals are scanned intermittently or intermittent transmitted signals are used. For example, each emission unit can send its telegram at predetermined intervals (e.g. every 5 seconds), said telegram containing both an identification code and information to be transmitted. The telegram can consist of a plurality of parts, e.g. a plurality of short parts in time, in which a signal is actually transmitted, which are in each case separated by a pause of a specific duration in time.

The individual telegram parts in which a signal transmission takes place can be so short that for these a discreet value can in each case be detected for the average value of the relevant modulating signal without having to generate an excessively high integrating action in view of the dependence

of the signal in time on a possible change in the angle
position of the relevant wheel. As an additional
characteristic variable for the reception signals, the number
of these discrete reception signal values which is greater or
less than a predetermined discriminator threshold value can
then be determined, in which case a minimum number of such
discrete reception signal values is preferably detected for
each reception signal and the relative frequency of the
reception signal values above or below the threshold value is
determined for each reception signal.

The allocation can then take place in such a way that those N
reception signals or emission units are allocated to the first
transmitter group producing the N highest relative
frequencies. The allocation to the second transmitter group
takes place for those M reception signals or emission units
for which the M lowest relative frequencies are produced.

In this case the allocation can be undertaken very generally
by detecting the identification code of the relevant reception
signal and its allocation to the relevant transmitter group.

As a test of the reliability of the allocation using the
determined relative frequency values, the minimum difference
in amount of the relative frequency values can be determined
for all the reception signals of the first and second

-10-

transmitter group (i.e. the difference in amount of the minimum relative frequency value for a reception signal from the first transmitter group and the maximum relative frequency value for a reception signal from the second transmitter group) and compared with a predetermined additional reliability threshold value, in which case a positive test result is assumed if the minimum difference in amount is greater than the additional reliability threshold value and in which case a negative test result is assumed if the minimum difference in amount is less than the additional reliability threshold value.

According to the preferred embodiment of the invention, the discriminator threshold value can then be determined depending on the characteristic parameters of the relevant reception signals. In this case, the discriminator threshold value can then, for example, depending on the detected average values of the smallest reception signal of the first transmitter group and the largest reception signal of the second transmitter group, be determined preferably at a relative interval from one of the average values of these two reception signals or as a ratio with regard to one of the average values of these two reception signals.

By means of this method, a drift in the average powers of the reception signals can be compensated for. To this end, a

-11-

predetermined starting value is preferably used for the discriminator threshold value in an initial state of the method. In the case of a repeated implementation of the method, the discriminator threshold value which has been determined anew in the preceding allocation process can then be used in subsequent methods. This has the advantage that it requires both minimal computation effort and a small memory. This is as a result of the fact that each reception signal only requires one numerator which represents the number of values above or below the discriminator threshold value.

If the computation efforts and the memory capacity are not important, then all the discrete values for the reception signals can as a matter of course also be stored and determined within the framework of a corresponding evaluation of the optimum discriminator threshold value. This can then also be used for the current allocation method.

Further embodiments of the method and the device according to the invention can be found in the subclaims.

The invention is described in more detail with reference to the drawings and on the basis of the preferred embodiments. They are as follows

Fig. 1 a schematic diagram of a motor vehicle with a device

for monitoring at least one parameter for a plurality of wheels pertaining to a motor vehicle and

Fig. 2 diagrams with exemplary fictitious curves of reception signals depending on the angle position of the relevant wheel.

The motor vehicle 1 shown schematically in Fig. 1 has a device 3 for monitoring at least one parameter for a plurality of wheels pertaining to a motor vehicle 1 and which includes a central evaluation and control unit 5 and four detector units 7, 9, 11, 13. The device 3 includes or at the same time serves as a device for localizing the position of emission units. One detector unit 7, 9, 11, 13 is allocated to one of the wheels 15, 17, 19, 21 of the motor vehicle 1 or fitted to said wheel and also fitted to said wheel when it is rotating.

Each of the detector devices 7, 9, 11, 13 includes an emission unit 7a, 9a, 11a, 13a. Each of the emission units 7a, 9a, 11a, 13a transmits a short frequency or phase-modulated signal at predetermined times which, for the sake of information, includes a specific identification code for each detector device 7, 9, 11, 13 and possibly a value for the parameter of the wheel to be monitored. However, the latter is not required in the allocation mode. The specific identification code and the value of the parameter are preferably implemented in the form of digital information or in the form of a digital signal which is used as a modulation signal for the carrier signal of

the transmitted signal.

The signals sent by the detector units 7, 9, 11, 13 or their
emission units 7a, 9a, 11a, 13a are received by the evaluation
5   and control unit 5 by means of one of these included receiver
units 23. The receiver unit 23 demodulates the reception
signal and in this way enables the evaluation and control unit
5 to preferably evaluate the digital information signals, i.e.
the specific identification code and the value for the
10 parameter to be monitored. However, the latter is only
mandatory in the normal monitoring mode.

The evaluation and control device 5 carries out collision
monitoring which, if a plurality of detector units 7, 9, 11,
15 13 transmit at the same time, prohibits an evaluation.

In order to avoid the costs of a bidirectional signal
transmission between the detector units and the evaluation and
control unit, the detector units can be embodied in such a way
20 that they transmit their signals at random intervals in time,
in which case a specific range of values can of course be
provided for the interval in time. This avoids two detector
units always transmitting simultaneously at the same intervals
over a longer period in time.

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The periodically transmitted signal (telegram) can, for

-14-

example, be transmitted at a predetermined interval of a few seconds and have a telegram duration of a few hundred milliseconds. The telegram can consist of a plurality of parts, e.g. a plurality of short parts in time in which a

5   signal is actually transmitted, which are in each case separated by a pause of a specific duration in time.

During normal operation, the evaluation and control unit 5 from the specific identification code of a reception signal

10   alone, can make an allocation of the value for the parameter to be monitored to the position of the wheel because in an allocation mode previously carried out, the allocation of each specific identification code to a position of the wheel was made and stored.

15

The allocation mode can, for example, be activated by the fact that each of the detector units 7, 9, 11, 13 includes a sensor (not shown) which reacts to accelerations in which case the detector units switch to the allocation mode if no

20   acceleration and with that no rotation of the wheels is detected for a specific time span. In the allocation mode, the signals can be transmitted at shorter intervals than is necessary during normal operation. Because of this, a quicker implementation of the allocation process is made possible. In

25   the allocation mode, it is not mandatory that the signals also have to contain information about a value of the parameter to

be monitored. It is more than sufficient in this case if a signal contains the specific identification code of the relevant detector unit 7, 9, 11, 13.

5   At this point it should be mentioned that the duration of a signal in time (implied here is the duration of a telegram part while a signal is actually transmitted) in both normal operation and in the allocation mode is small compared to the duration in time required by a wheel in the case of a maximum

10   permissible speed for a full revolution. Typically, the duration in time of a signal is approximately 1 millisecond to 100 milliseconds, for example, 10 milliseconds. This short signal duration makes it possible, via the average signal power at the receiving point of the evaluation and control

15   unit 5, to characterize the associated angle position of the relevant wheel without an undesired integrating effect being generated by the rotation of the wheel.

In the allocation mode, the evaluation and control unit 5

20   detects the average signal power at the receiving point in which case for this purpose, the receiver unit 23 generates a signal which represents a measurement for the average signal power of the received phase-modulated or frequency-modulated signals.

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Fig. 2 shows a fictitious example of the four signal curves of

-16-

the reception signals of the individual emission units 7a, 9a, 11a, 13a depending on the angle position of the relevant wheels. Because in the said embodiment, only a short telegram section of the signal or its average value is always detected, the signal curves shown in Fig. 2 are produced if a plurality of such discrete values would be detected for each reception signal and the angle position allocated.

However, for the desired simple evaluation, the computation efforts should not be extensive and the memory should be kept as small as possible so that a detection of the angular position of the wheels should also be dispensed with if possible. Also storing the individual discrete values for the relevant reception signals should be dispensed with if possible.

To this end, the individual discrete values of the reception signals can be summed and averaged. In this case, the evaluation and control unit controls the detection processes in such a way that for each reception signal a minimum number of values, for example, 64 values are detected. There is no requirement here for the same number of discrete values to be detected for each reception signal.

The average values (shown as a dashed line in Fig. 2) determined in such a way for each reception signal can then be

-17-

used for the allocation process. For reasons of a more simple
and reliable localizing (allocation of a reception signal to
an emission unit or its local position), only axle localizing
is carried out below. To this end, for a specific reception
signal it should only be determined whether or not the
relevant emission unit is in the wheel positions on the front
axle or the rear axle of the motor vehicle. Because
standardized emission units with more or less the same
transmitting power are usually used, the receiver antenna of
the receiver unit is preferably fitted asymmetrically in the
motor vehicle, closer to the front axle of the motor vehicle
1, for example, as shown in Fig. 1. That is why the averaged
discrete values of the reception signals, for the emission
units 7a, 9a, in the wheel positions on the front axle are
higher than the averaged discrete values of the reception
signals for the emission units 11a, 13a in the wheel positions
on the rear axle. This can also be seen from the fictitious
signal curves in Fig. 2. For the reception signals in Figs. 2a
and 2b in the case of the emission units in the wheel
positions of the rear axle, lower average values are produced
than in the case of the emission units in the wheel positions
of the front axle. However, the average values in the wheel
positions of the same axle can hardly be differentiated.

The allocation which is carried out in the allocation mode of
the evaluation and control unit (5), can in this simple case

-18-

of axle localizing simply be brought about by allocating the two reception signals with the higher average values to the front axle and the two reception signals with the lower average values to the rear axle. The actual allocation takes place by storing the identification code of the emission units for the relevant information or region information (i.e. for example "front axle" or "rear axle").

However, also the differences in the average values of the different axles can be relatively small so that it should be examined whether or not the allocation or localizing carried out in such a way produces a sufficient reliability.

To this end the minimum interval of the average values of the reception signals of the two emission units on the front axle can be determined from the average values of the reception signals of the two emission units on the rear axle. In other words, the lowest average value of the relevant reception signal of an emission unit on the front axle is compared with the highest average value of the relevant reception signal of an emission unit on the rear axle. Instead of using an absolute difference in amount of the values to be compared it is recommended that a ratio of the two values be used in which case the reliability of a correct localizing increases with the interval of the quotient of 1. Below it is assumed that the quotient is formed in such a way that the higher value

-19-

stands in the numerator position and the lower value in the

denominator position in each case, i.e. the quotient is

basically higher than 1. The ratio determined in this way is

compared with a threshold value of reliability in which case a

5   correct allocation is assumed if the quotient is greater than

the threshold value of reliability. In this case, the

localizing process ends.

If the quotient is less than the threshold value of

10   reliability, an additional criterion is used for the

allocation.

For this purpose, the number of discrete values detected for

each of the reception signals which lie above a predetermined

15   discriminator threshold value is for example suitable. This

discriminator threshold value will preferably be selected in

such a way that it is between the lowest average value of the

reception signals of the control units on the front axle and

the highest average value of the reception signals of the

20   emission units on the rear axle. The optimum position of the

discriminator threshold value in this case depends on the

fictitious curve of the reception signals as a function of the

position of the wheel (cf. Fig. 2). As starting value for the

discriminator threshold value, a predetermined fixed value or

25   a value with a predetermined interval from the lowest average

value of the reception signals of the emission units on the

front axle can be selected. Therefore, the interval can be predetermined as an absolute value or as a ratio with regard to the relevant average value.

5   The discriminator threshold value can also be determined anew in the case of each localizing process. However, it is also possible that the new discriminator threshold value is only used in the next localizing process in each case if the individually detected, discrete average values are not stored.

10

Because of this, a method is developed which adapts itself automatically to possible changes in the parameters or the environmental conditions. In this way, it is in particular possible that the effects of a drift of the transmitting power

15   can be compensated for or moderated.

The allocation or localizing then again takes place in such a way that the two reception signals which supply most of the values above the discriminator threshold value or the relevant

20   emission units are allocated to the front axle and the two reception signals which supply the fewest values above the discriminator threshold value or the relevant emission units are allocated to the rear axle. Instead of the absolute numbers for values above the discriminator threshold value,

25   relative frequencies can also be used. These are determined by dividing the absolute numbers by the number of values actually

detected for the relevant reception signal.

The allocation result which is determined with this additional decision criterion can also be checked with regard to the
5   presence of sufficient reliability with a suitable reliability criterion. For this purpose, the interval of the relative frequencies of the reception signals which have the second and third highest frequencies can for example be examined; in other words, the reception signal is used which is allocated
10 to the front axle according to the relevant allocation criterion and, of the reception signals of the emission units of the front axle, has the lowest frequency value, and the reception signal which is allocated to the rear axle according to the relevant allocation criterion and, of the reception
15 signals of the emission units of the rear axle, has the highest frequency value. To this end, the interval of the relative frequencies can then again be expressed relatively, i.e. as a ratio or an absolute value. By comparing the interval with an additionally predetermined reliability
20 threshold value, a statement can be made with regard to a sufficient or insufficient reliability for the allocation carried out according to the relevant allocation criterion.

If the application of this additional allocation criterion
25 produces the same allocation as the allocation criterion previously used and if this reliability test produces a

-22-

positive statement, i.e. if the interval is greater than the reliability threshold value (for the case that the relative frequencies are compared by the formation of a ratio, if a quotient greater than 1 should again be assumed), the allocation process ends successfully.

If the allocation leads to another result, the method is terminated as unsuccessful and started anew and/or an error signal or an error message generated.

Should the allocation lead to the same result, but the reliability test does not signal a sufficient reliability, a third allocation criterion is used according to the special embodiment explained here.

For this purpose, the maximum value or the minimum value is in each case determined while detecting the discrete average values for the reception signals. In this case it is also assumed that the reception signals of emission units on the front axle in each case have higher maximum values or lower minimum values than the reception signals of the emission units on the rear axle and have carried out a corresponding allocation.

However, if this allocation also leads to the same result as the application of the two allocation criteria previously

explained, the method ends successfully, otherwise it is terminated as unsuccessful and restarted and/or an error signal generated.

5 However a corresponding reliability criterion can of course also be used for this method, for example the interval between the maximum values and/or the minimum values which can be determined analogously to the method described above and compared with a reliability threshold value. In the case of a

10 negative reliability statement, an unsuccessful termination of the method could then also be carried out.

This produces a method and a device which overall make it possible, in the simplest way and with the required

15 reliability, to carry out an allocation or localizing of the reception signals or the corresponding transmission units to positions or regions.